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032904

PTO/SB/16 (01-04)
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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

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INVENTOR(S)		
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Additional inventors are being named on the 1 *separately numbered sheets attached hereto*

TITLE OF THE INVENTION (500 characters max)

LANDING GEAR NOISE ATTENUATION

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ENCLOSED APPLICATION PARTS ***(check all that apply)***

☑ Specification *Number of Pages* 18

☑ Drawing(s) *Number of Sheets* 28

☐ Application Data Sheet. See 37 CFR 1.76

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☐ Other (specify)

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

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Respectfully submitted,

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Date March 29, 2004

REGISTRATION NO. 34,180
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Docket Number: G1371020.1 50447.3.6

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Docket Number G1371020.1 50447.3.6

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TOTAL AMOUNT OF PAYMENT ($) 160

Complete if Known	
Application Number	
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First Named Inventor	Jeffrey W. Moe et al.
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FEE CALCULATION

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1001	770	2001	385	Utility filing fee	
1002	340	2002	170	Design filing fee	
1003	530	2003	265	Plant filing fee	
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2. EXTRA CLAIM FEES FOR UTILITY AND REISSUE

			Extra Claims		Fee from below		Fee Paid
Total Claims		-20** =		X		=	
Independent Claims		- 3** =		X		=	
Multiple Dependent						=	

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
1202	18	2202	9	Claims in excess of 20
1201	86	2201	43	Independent claims in excess of 3
1203	290	2203	145	Multiple dependent claim, if not paid
1204	86	2204	43	** Reissue independent claims over original patent
1205	18	2205	9	** Reissue claims in excess of 20 and over original patent

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FEE CALCULATION (continued)

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1052	50	2052	25	Surcharge - late provisional filing fee or cover sheet	
1053	130	1053	130	Non-English specification	
1812	2,520	1812	2,520	For filing a request for *ex parte* reexamination	
1804	920*	1804	920*	Requesting publication of SIR prior to Examiner action	
1805	1,840*	1805	1,840*	Requesting publication of SIR after Examiner action	
1251	110	2251	55	Extension for reply within first month	
1252	420	2252	210	Extension for reply within second month	
1253	950	2253	475	Extension for reply within third month	
1254	1,480	2254	740	Extension for reply within fourth month	
1255	2,010	2255	1,005	Extension for reply within fifth month	
1401	330	2401	165	Notice of Appeal	
1402	330	2402	165	Filing a brief in support of an appeal	
1403	290	2403	145	Request for oral hearing	
1451	1,510	1451	1,510	Petition to institute a public use proceeding	
1452	110	2452	55	Petition to revive - unavoidable	
1453	1,330	2453	665	Petition to revive - unintentional	
1501	1,330	2501	665	Utility issue fee (or reissue)	
1502	480	2502	240	Design issue fee	
1503	640	2503	320	Plant issue fee	
1460	130	1460	130	Petitions to the Commissioner	
1807	50	1807	50	Processing fee under 37 CFR 1.17(q)	
1806	180	1806	180	Submission of Information Disclosure Stmt	
8021	40	8021	40	Recording each patent assignment per property (times number of properties)	
1809	770	2809	385	Filing a submission after final rejection (37 CFR 1.129(a))	
1810	770	2810	385	For each additional invention to be examined (37 CFR 1.129(b))	
1801	770	2801	385	Request for Continued Examination (RCE)	
1802	900	1802	900	Request for expedited examination of a design application	

Other fee (specify) ____________

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SUBMITTED BY				(Complete *(if applicable)*)	
Name *(Print/Type)*	Jack B. Hicks	Registration No. *(Attorney/Agent)*	34,180	Telephone	336-574-8050
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Sir:

CERTIFICATE OF MAILING/EXPRESS MAIL

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Date of Deposit: March 29, 2004

I hereby certify that this paper, which is a Provisional Patent Application entitled LANDING GEAR NOISE ATTENUATION (Our File No. G137 1020.1 (50447.0003.6)), and the attached fee are being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 C.F.R. 1.10 on the date indicated above and is addressed to the MAIL STOP PROVISIONAL PATENT APPLICATION, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Jack B. Hicks
Jack B. Hicks
Registration No. 34,180

Mailed By: Lisa M. Carter
Lisa M. Carter

W1296706

LANDING GEAR NOISE ATTENUATION

FIELD OF THE INVENTION

This invention relates to landing gear noise attenuation and more specifically to apparatus intended to mitigate airframe landing gear noise.

BACKGROUND

The interaction of airflow with an airframe's protrusions and cavities creates airframe noise. While engine noise dominates aircraft noise at takeoff, the airframe noise created by landing gear is a substantial contributor to approach noise for many aircraft. During approach, an aircraft engine is operating at less power than that during takeoff. Hence, the noise from the airframe is comparable to that of the engine noise.

The landing gear of commercial aircraft represent a complex system of wheels, axles, trucks or bogie beams, brakes, cable harnesses, torque links, braces, structure interfaces and wheel hubs. Skilled landing gear designers traditionally have emphasized the operational parameters attendant to proper deployment, operation and retraction of landing gear, and have not previously been directed to address noise attenuation as a design priority. While various noise reduction designs are known for fixed landing gear, noise attenuators for retractable landing gears are less developed.

There is a need for retractable landing gear attenuation structures that successfully reduce noise emanating from the landing gear acoustic signature. The complexity of non-acoustical constraints on the design of landing gears have not permitted effective and practical noise minimization designs.

SUMMARY OF THE INVENTION

In accordance with a preferred embodiment of this invention, a landing gear noise attenuator comprises a noise reduction apparatus that is on a member of a conventional retractable landing gear. The apparatus can have a first position when the landing gear is in its down or deployed position, and a second position when the landing gear is in its up or stowed position.

These and other aspects of the present invention will become apparent to those skilled in the art after a reading of the following description of the preferred embodiments, when considered in conjunction with the drawings. It should be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1 through 3 are views of a conventional landing gear.

Figure 4 is a landing gear containing fairings of the present invention.

Figure 5 is a partial isometric view of a landing gear containing fairings of the present invention.

Figure 6 is a partial underside view of a landing gear containing fairings of the present invention.

Figures 7A and 7B are views of a truck and fairing of the present invention.

Figure 8 is a truck fairing of the present invention.

Figure 9 is an end view of a truck fairing of the present invention.

Figure 10 is a brake fairing of the present invention.

Figure 11 shows structural fairings of the present invention.

Figures 12A and 12B show structural fairings of the present invention.

Figures 13A and 13B are door/shock strut interface fairings of the present invention.

Figures 14A – 14D are door/shock strut interface fairings of the present invention.

Figure 15 is a shock strut fairing of the present invention.

Figure 16 is a system diagram of the components for inflatable fairings of the present invention.

Figure 17 is a front left view showing landing gear fairings of the present invention.

Figure 18 is an aft view showing landing gear fairings of the present invention.

Figure 19 is a section view of an inflatable fairing and girt of the present invention.

Figure 20 is a sectional view of an outer girt construction of the present invention.

Figure 21 is an inflatable truck fairing of the present invention, with wheels removed for clarity.

Figure 22 is an underside view of a truck fairing of the present invention.

Figure 23 is an aft view of a truck fairing of the present invention.

Figure 24 are drag strut fairings of the present invention.

Figure 25 is a sectional view of a drag strut fairing of the present invention.

Figure 26 is a view of fairings of the present invention.

Figure 26 is a pressure reservoir and regulator of the present invention.

DETAILED DESCRIPTION

Landing gear fairings are an effective approach to reduce noise. Fairings improve the aerodynamic characteristics of the landing gear system, such that the unsteadiness of the airflow is minimized. While fixed fairings have been used traditionally for non-retractable landing gear, the employment of fairings in conjunction with retractable landing gear is limited due to the confined space of the fuselage nose section and of the relatively thin wing sections.

Due to size constraints, a full enveloping fixed fairing for a landing gear is not feasible. Alternatively, significant noise attenuation is achievable by partially fairing critical components of landing gear.

Figures 1, 2 and 3 illustrate a conventional main landing gear 10. For ease of illustration, certain cable harnesses and hydraulic lines are not shown. Landing gear 10, shown in a deployed position, includes wheels 12, axles 14, trucks or bogie beams 18, brakes 22, cable harnesses (not shown), torque links 30, struts 32, braces 34, structure interfaces 38, wheel hubs 42 and door 46. Unless otherwise stated, the terms "down or deployed position" mean when the landing gear is deployed, but prior to contact with a runway or other landing surface.

Selected landing gear components are suitable for adaptation, modification or redesign featuring aerodynamic components. Figures 4 illustrates several types of fixed fairings covering or shielding selected landing gear components.

As shown in Figures 4, 5 and 6, a truck fairing 210 can cover the forward end, underside, and aft end of the truck beam, respectively. The truck fairing 210 also can extend to cover the brakes 22, and certain wire harness (not shown). In another embodiment, the truck fairing 210 may extend to cover the torque links 30. Figure 5 shows an isometric view

of the fairing 210 covering the truck beam 18, axles 14, and brakes (partially) 22 on a landing gear. Figure 6 shows a view from the underside of the landing gear.

The truck fairing 210 may be a rigid structure, or may consist of a rigid lower fairing and a smart, or retractable, upper fairing. To accomplish a smart or retractable upper truck fairing, a localized torque link fairing along with bundled, shielded or rerouted cable harnesses may be employed. Alternatively, a truck fairing, or combination of fairings, that retract or rotate after landing to allow air flow for brake cooling, access to the tow fitting, and access to the jacking pad can be employed. The movement of the smart upper fairing can be accomplished by adding a powered hydraulic or electrical system to drive the fairing. An alternative approach would be to use the stroking of the gear to static position and kinematics of braces or links to drive the fairing. In other words, as the landing gear goes through its deployment stage on approach, the hydraulic and/or electrical systems that are used to deploy the gear to its final, fully extend position can also be used to operate/deploy a smart upper truck fairing that addresses the torque link, forward and rear cable harness noise sources. Implementation of such methods and techniques are known to those of skill in the art.

The design of truck fairing 210 can reflect several design considerations. The fairing accommodates access to the jacking pads, tow fitting, and brakes 22. The lower portion of the fairing 210 blocks a substantial portion of the underside of the truck 18, but retains room for tire clearance. The truck fairing 210 can present a location for the collection of debris, and ease of inspection (and removal of such debris) is required. The truck fairing 210 also must be shaped and configured to allow for retraction and stowing of the gear in selected aircraft associated with the landing gear 10.

Figures 7A, 7B, 8 and 9 illustrate preferred layouts of the truck fairing 210. For certain types of landing gear, installation of the fairing 210 will require modification of the existing gravel shields, which can be mounted to the two junction boxes on the underside of

trucks. To assemble fairing 210, the design can comprise one or more separate fairing sections. Four fairing sections 214, 216, 218, 220 are shown in Figures 7A, 7B, 8 and 9. Three of these fairings 214, 216, 218 can cover the underside of the truck 18, brake rods and brakes, with a fourth section 220 secured onto the tow fitting to cover the forward truck, tow fitting, jacking pad, and front brakes. The fairing 210 can be made of any aerospace-grade metal alloy, or of a suitable composite material, sheet metal or plastic.

The truck fairing 210 can be secured to the landing gear 10 in various manners. For example, standard fasteners already used on the landing gear truck 18 could be lengthened and used to restrain the fairings to existing brackets. Alternatively, band clamps 224 or other suitable forms of securing could be used to secure the fairing 210 to the truck 18.

The truck fairing 210 has several design considerations. This fairing provides foreign object and debris protection to the truck 18. The fairings, suitably designed to withstand such impacts, will decrease the overall number of maintenance and repair requirements generated from foreign objects impacting the gear. The fairing 210 can be designed for ease of maintainability. Preferably, the design minimizes the removal and maintenance of the fairing 210, or, alternatively, if removal is needed, the removal and installation procedures are simple enough to not significantly increase the task time required for routine maintenance. In another preferred embodiment, drain holes are incorporated in the fairing to allow removal of any hydraulic fluid or other liquids that may gather in the normal course of landing gear operation and servicing. Routine inspections can be performed to ensure that any foreign objects or debris, including rocks, safety wire, etc., has not collected in the fairing. If an actively driven smart fairing is installed on the truck 18, a routine inspection of the hydraulic or electrical system used to drive the smart fairing will be necessary.

Figure 10 illustrates a fixed brake cover fairing 240. Fairing 240 streamlines the airflow over the brakes by partially covering the piston and piston housing of the front brakes.

The less than full circumferential design of the fairing 240 promotes cooling to minimize the effect of the fairing on brake performance and to promote brake cooling while the aircraft is parked at the gate.

Alternatively, the fairing 240 may also incorporate smart fairing components that retract out of the way while the aircraft is on the ground to facilitate brake cooling. The design of fairing 240 may also incorporate brake cooling ducts to help decrease the time required for brake cooling.

In addition, or in the alternative, to a separate brake cover fairing 240, a brake fairing concept can be incorporated into the lower truck fairing design 210. As shown in Figures 7A and 7B, the truck fairing 240 partially covers the front brakes on the landing gear. The fourth piece 220 of the truck fairing can be secured to the tow fitting and cover the front brakes on landing approach.

Figures 11 through 12 illustrate fairings used to minimize noise emanating from cavities and pockets in structural members. These fairings 260, 264 provide aerodynamic shapes to the braces 34 of the landing gear to reduce wakes generated by the braces, as well as filling in open ended pins. "Pocket filler" fairing inserts 260 can comprise low weight foam material, plastic, composite and/or metal alloy insert. The use of plastic and/or metal (such as aluminum) as opposed to a foam insert increases weight, but may be easier to attach to the structure and decreases the concern for possible foreign object and debris damage.

Fairings 260 can also comprise acetal resin inserts, such as Dupont's Delrin® resin, that fit inside the pockets of the side and drag braces. These inserts can be restrained to the braces using existing attachment slots in the pockets. The shallow pockets on the sides of the braces do not necessarily require inserts, only the deeper pockets on the top and bottom of the braces. End caps also can be installed in hollow pins 35 about the gear. Known manufacturing practices can be utilized to manufacture the filled braces.

As shown in Figure 12A, fairing 264 can be designed to have a bulbous front section 265, and a tapered rear section 263, to help minimize noise generation.

The "pocket filler" fairings 260 can be designed to allow for ease of installation and removal. As shown by the filled brace pockets of Figure 12B, installation can be by traditional removable or non-removable fasteners 267. Alternatively, in new construction, the braces can be fabricated without any pockets or cavities. When removable fasteners 267 are used, the fasteners 267 allow ease of removal of the fairings for inspections for potential cracking and corrosion of the structural members underlying the fairings, as well as inspections for moisture that may collect between the fillers and structural members.

Figures 13 and 14 illustrate door/shock strut interface fairings. These fairings reduce noise by eliminating the gap between the door 46 and strut 50. In the case of fairing 280, the gap is eliminated by making modifications to the edges of the door shape, and inserting a fairing 280 in the gap between door and the strut. As shown in Figure 13B, a fairing 284 can be attached to the door or shock strut.

In another embodiment, as shown in Figures 14A – 14D, a door/strut interface noise reduction fairing 288 comprises a multi-piece fairing that attaches to the shock strut via the existing hydraulic and electrical brackets along its length. The fairing extends from the door around the front of the shock strut and around the side of the gear, incorporating the shock strut concept. The door to shock strut and systems fairing can be made of aerospace grade aluminum alloys; alternatively, other materials including composite structures may be used.

Figure 15 shows a tear drop shock strut fairing 292 that extends from the interface gap around the front of the shock, covering the electrical and hydraulic lines that run along the front of the shock strut. Such a fairing can be added as a retrofit to an existing strut, or incorporated into a design of a new landing gear strut. During operation, the shock strut fairing 292 is designed to allow the shock strut to function both in the deployed but pre-

touchdown position, and also in the post-runway, compressed position. This function is permitted by the fairing internal construction allowing for sufficient clearance for compression of the shock strut when the landing gear contacts the runway or ground surface during landing. The attachment points of the fairing 292 also avoid interference with such shock strut compression.

The fairings as described herein can be installed and removed, ideally, by a single individual. Sharp edges on the fairing should be avoided in order to avoid creating safety hazards. Benefits for these fairings may include a reduction in the size and weight of the dressings that these fairing would protect. In addition to aiding noise reduction, the fairings of this invention may also act as a foreign object and debris deflector, reducing the need to increase the material size of the dressings that the fairings protect.

In another preferred embodiment, a deployable fairing can operate to deploy upon extension of the landing gear, and then retract when the landing gear is stowed within the nose section and wing sections. A landing gear fairing, for example, can inflate when the landing gear is deployed, and deflate when the fairing is not required or desired.

As shown in Figure 16, the deployment and retraction of the inflatable fairings preferably is achieved through air pressure actuation and retraction. When the landing gear is deployed, a pressure regulator 101 can be triggered to inflate the fairings 510, 520, 530 as the landing gear comes into the air stream. A 400 cubic inch reservoir 114 can be charged to approximately 2,000 psig with air to inflate the fairings. A compressor 118 can charge the reservoir 114 to approximately 2,000 psig pressure. A vacuum pump 122 can deflate the fairings once the airplane is on the ground. The fairings can stay deflated during airplane takeoff. The vacuum applied to the fairings can keep the fairings from excessive movement or flapping in the air during takeoff. Alternatively, bleed air 126 from the engine can be used

to charge the reservoir and an engine vacuum device 127 can apply a vacuum pressure thereby eliminating the need for a compressor and vacuum pump.

Figures 17 and 18 illustrate several additional embodiments for noise reduction attenuation. The deployed fairings 540, 580, 600, 620, 630, 640, 650 form an aerodynamic shape around various components of the landing gear when the fairings 540, 580, 600, 620, 650 are inflated in a preferred embodiment to approximately 2.5 psig pressure. In the embodiments shown, a torque link fairing panel 630 and door panel fairing 640 are non-inflatable fabric panels that are deployed on, around, or between components of the landing gear and the inflatable fairings 540, 580, 600, 620, 650. As will be apparent to persons of ordinary skill in the art, other combinations of inflatable and non-inflatable fairings also may be used. For example, door panel fairing 640 may include an inflatable portion that at least partially fills a space between the main strut and door panel on a landing gear, and blocks or deflects noise-producing air flows that would otherwise pass between the main strut and door panel. The shape of the inflatable fairings can vary, depending upon aerodynamic or space configuration requirements.

Each inflatable fairing 540, 580, 600, 620, 650 can contain one or more inflatable chambers there within. Each inflatable chamber may require one pressure relief valve 505. The materials forming the inflatable fairings can comprise any material that is flexible and suitable for pressurization. The exterior of the fairings should be tear-resistant and capable of withstanding the environment encountered by aircraft during takeoff and landings. To minimize damage from debris impact, at least portions of some outer surfaces of the fairings can be made from Kevlar® fibers or other suitable durable fibers and material. To minimize weight, the use of high strength fibers such as Kevlar® fibers can be limited to debris impact areas only. The fairings can be secured to the structure using a girt arrangement as discussed below.

As shown in Figures 17 and 18, an embodiment of an inflatable fairing system may include a main strut fairing 540, a forward drag strut fairing 650, an aft drag strut fairing 600, a torque link fairing 620, a torque link fairing panel 630, a door panel fairing 640, and a truck fairing 580. As shown in Figures 2, 8, and 9, an inflated and deployed main strut fairing 540 surrounds a large portion of the main strut of the landing gear. As shown in Figures 17, 18, 22, and 24, an inflated and deployed aft strut fairing 600 envelopes all or most of the aft drag strut of the landing gear. Figures 15, 22, 24, and 25, show an inflated and deployed forward drag strut fairing 650 positioned around the forward drag strut of the landing gear. The inflatable fairings 540, 600, 650 provide the main, aft, and forward struts with enhanced aerodynamic profiles.

Figure 19 shows a cross-section of one embodiment of an inflatable fairing 100 according to the invention. In this embodiment, the fairing 100 includes an inner girt 120 and an outer girt 130. The inner and outer girts 120, 130 are joined together on either side 106, 108 of a separation 105 such as by stitching and/or adhesives. The separation 105 in the girts 120, 130 permits the fairing 100 to be wrapped around a structural member of a landing gear such as a strut. Laces 110 may be used to connect edges 106, 108 and to tighten and securely retain the inner girt 120 on the enveloped structural member 200. The laces 110 may be a nylon cords, for example. Grommets may be provided along adjacent edges 106, 108 for receiving the laces 110. Other tightening and retaining means also may be used such as straps, buckles, or the like. An inflation tube 134 is disposed between the inner girt 120 and outer girt 130 on at least one side of the structural member 200. Preferably the inflation tube is positioned opposite the laces 110. One or more hoses 104 is used to supply and extract air from the inflation tube 134. When the inflation tube 134 is inflated between the inner girt 120 and outer girt 130, the outer girt 130 takes on an enhanced aerodynamic profile like that shown in Figure 19. More than one inflation tube 134 can be used between the inner and

outer girts 120, 130 to provide the fairing 100 with a desired shape when inflated. The inner girt 120 secures the inflatable fairing to the structure 200, while the outer girt 130 is used to provide the shape of the fairing.

Inner girt 120 can be made from various pliable materials including, for example, a woven nylon fabric coated with polyurethane. Such materials presently are used to construct inflatable evacuation slides for commercial aircraft, for example. Outer girt 130 may be made from a combination of typical girt material and a highly durable material, such as Kevlar® fiber, to protect the inflatable fairing from debris during landing. Figure 20 shows the construction of one embodiment of the outer girt 130, comprising an outer debris-resistant layer 136, a girt material layer 138, and the inflation tube 134. Preferably, the outer debris-resistant layer 136 and girt material layer 138 are stitched and/or bonded to one another. The girt material 138 and inflation tube 134 may be bonded to one another such as by a suitable adhesive.

Returning to Figure 17, a main strut fairing 540 is shown in its deployed position. The main strut fairing substantially envelopes the main strut of the landing gear, providing an aerodynamic profile to attenuate noise during landing. The main strut fairing 540 covers an outer cylinder (not shown) of a conventional landing gear. During touchdown, as the inner cylinder (not shown) of the landing gear moves within the outer cylinder, the main strut fairing 540 can move relative to other components on the landing gear.

During operation, the main strut inflatable fairing 540 is designed to allow the shock strut to function both in the deployed but pre-touchdown position, and also in the post-runway, compressed position. This function is permitted by the inflatable fairing internal construction allowing for sufficient clearance for compression of the shock strut when the landing gear contacts the runway or ground surface during landing. The attachment points of the fairing 540 also avoid interference with such shock strut compression.

A truck fairing 580 also is shown in Figure 17, as well as in Figures 11, 12 and 23. The truck fairing can wrap substantially around a conventional truck structure like that depicted in Figure 6. The top portion 582 of the truck fairing 580 can be secured by wrapping inner and outer girts around the truck. The bottom portion 586 of the truck fairing 580 can be secured by wrapping the inner and outer girts around an existing rock guard (not shown) under the truck. To keep the truck fairing 580 within the confines of the wheels of the landing gear, the inflatable fairing near the wheels can have specially shaped inner panels 585 like those depicted in Figure 13. As describe above, an inner girt is used primarily to secure the inflatable fairing to the truck and an outer girt primarily provides its shape. As shown in Figure 23, the truck fairing 580, when inflated, is designed essentially to stay within the boundaries of the wheels without touching them.

Figures 24, 25 and 26 illustrate the forward and aft drag strut fairings 600, 650. The fairings are secured to the forward and aft drag struts of the landing gear in the manner described above. As can be seen in Figure 25, an inner girt 651 can be used to secure the inflatable fairing 650 to the strut 660 and an outer girt 652 can be used to provide the shape to the fairing. The construction of the outer girt 652 preferably is the same as shown in Figures 19 and 20. The inner girt 651 can be secured to the strut 660 using conventional methods such as a cord to lace together the separation 655 in the inner and outer girts 651, 652.

As shown in Figures 17, 22 and 24, a door panel fairing 640 extends between a forward edge 641 of the landing gear door panel and a side or edge 643 of the main strut fairing 540. The door panel fairing 640 can be attached to the door panel edge 641 and the main strut fairing 540 by any suitable connector or adhesive. For example, the door panel fairing 640 can be attached to the door edge 641 with mechanical fasteners such as rivets (not shown), and can be attached to the main strut fairing 540 by stitching, adhesives, hook and loop fasteners, or the like. Girt fabric panels 640 can be bonded on the leading and trailing

edges 641 of the landing gear door to provide a smooth transition from the door edge to the main strut inflatable fairing. The down stream edge of the panel is attached to the main strut fairing 540 using conventional means, such as by bonding, Velcro® hook and loop fasteners, etc. When the main strut fairing 540 is inflated, the door panel(s) 640 will form an aerodynamic shape to reduce noise. In certain applications where the tension in the panel(s) 640 is not sufficient to take the air loads, the panel(s) 640 may be replaced with an inflatable door panel (not shown) that is constructed like the inflatable fairings described above, and is capable of withstanding the air loads.

Figure 18 depicts an inflatable torque link fairing 620. The inflatable torque link fairing 620 surrounds the torque link of a landing gear and provides this portion of the landing gear with a smooth, aerodynamic shape. The torque link fairing 620 may be attached to a top surface 582 of a truck fairing 580 that underlies the torque link fairing 620. The torque link fairing 620 is designed to cover the torque link without impairing the normal movement of the torque link when the airplane lands. As shown in Figure 17, and as further shown in Figures 18, 21, 23 and 24, a torque link fairing panel 630 is configured to wrap around a lower forward portion of the main strut of the landing gear and to extend aftward over each side of the inflated torque link fairing 620. The torque link fairing panel 630 may be attached to the sides of the torque link fairing by any suitable fastener or fasteners, such as hook and loop fasteners. The torque link fairing panel 630 is constructed of a suitable fabric that can be collapsed or compressed to permit relative vertical motion between the truck and strut of the landing gear.

A pressure regulator 101 and reservoir 114 are shown in Figure 27. In a preferred form of operation, reservoir 114 can inflate the fairings quickly, preferably within 2 to 5 seconds from the time inflation is initiated. The reservoir 114 can be any suitable size depending upon the volume of the inflatable fairings and charged to approximately 2,000 psig

pressure. In one preferred embodiment, the reservoir can have a volume of 400 cubic inches. An air compressor 118 on board the airplane can be used to charge the reservoir 114. The pressure regulator 101 controls the pressure of air flowing into the inflatable fairings 510, 520, 530. The pressure regulator 101 actuation can be triggered by the landing gear door opening mechanism. The pressure regulator 101 can be set at a predetermined setting as appropriate for the tubing and dynamics of each installation.

A compressor 118 can charge the reservoir to approximately 2,000 psig pressure so that the pressurized air can be used to inflate the noise reduction fairings at the time of landing. To keep the weight as low as possible, the compressor preferably is a low displacement type, high pressure device that is capable to charging a reservoir to 2,000 psig while the airplane is airborne. If bleed air from the engine can be use to charge the reservoir, the need for the air compressor will be eliminated.

A vacuum pump 122 can be used to remove air out of the inflated fairings once the airplane has landed. In most cases, the fairings can stay deflated during airplane takeoff. The vacuum applied to the fairings will keep them from moving or flapping in the air during takeoff. Maintaining the fairings in their deflated condition during takeoff also will better facilitate the articulation and movement of the landing gear struts during the gear stowage operation. If a bleed air ejector valve can be used to provide vacuum, the need for a vacuum pump can be eliminated. To assure that the fairings do not exceed the maximum designed pressure, a pressure relief valve 505 is preferred for each fairing. Alternatively, if the pressure can be adequately controlled by the regulator 101, the requirement for the pressure relief valves may be eliminated. High pressure hoses 104 as depicted in Figures 19 and 25 can be used to direct high pressure air to the inflatable fairings, as well as to deflate the fairings when desired.

While preferred embodiments of the present invention have been described above, it

is to be understood that any and all equivalent realizations of the present invention are included within the scope and spirit thereof. Thus, the embodiments depicted are presented by way of example only and are not intended as limitations upon the present invention. While particular embodiments of the invention have been described and shown, it will be understood by those of ordinary skill in this art that the present invention is not limited thereto since many modifications can be made. Therefore, it is contemplated that any and all such embodiments are included in the present invention as may fall within the literal or equivalent scope of the appended claims.

CLAIMS

We claim:

1. A landing gear noise attenuator for deployable landing gear comprising an apparatus having a first position, relative to the landing gear, when the landing gear is deployed, and a second position, relative to the landing gear, when the landing gear is not deployed.

ABSTRACT

A landing gear noise attenuator mitigates noise generated by airframe retractable landing gear. The attenuator can have a first position when the landing gear is in its deployed or down position, and a second position when the landing gear is in its up or stowed position. Inflatable fairings provide noise attenuation, and do not compromise limited space constraints associated with landing gear retraction and stowage.

PRIOR ART

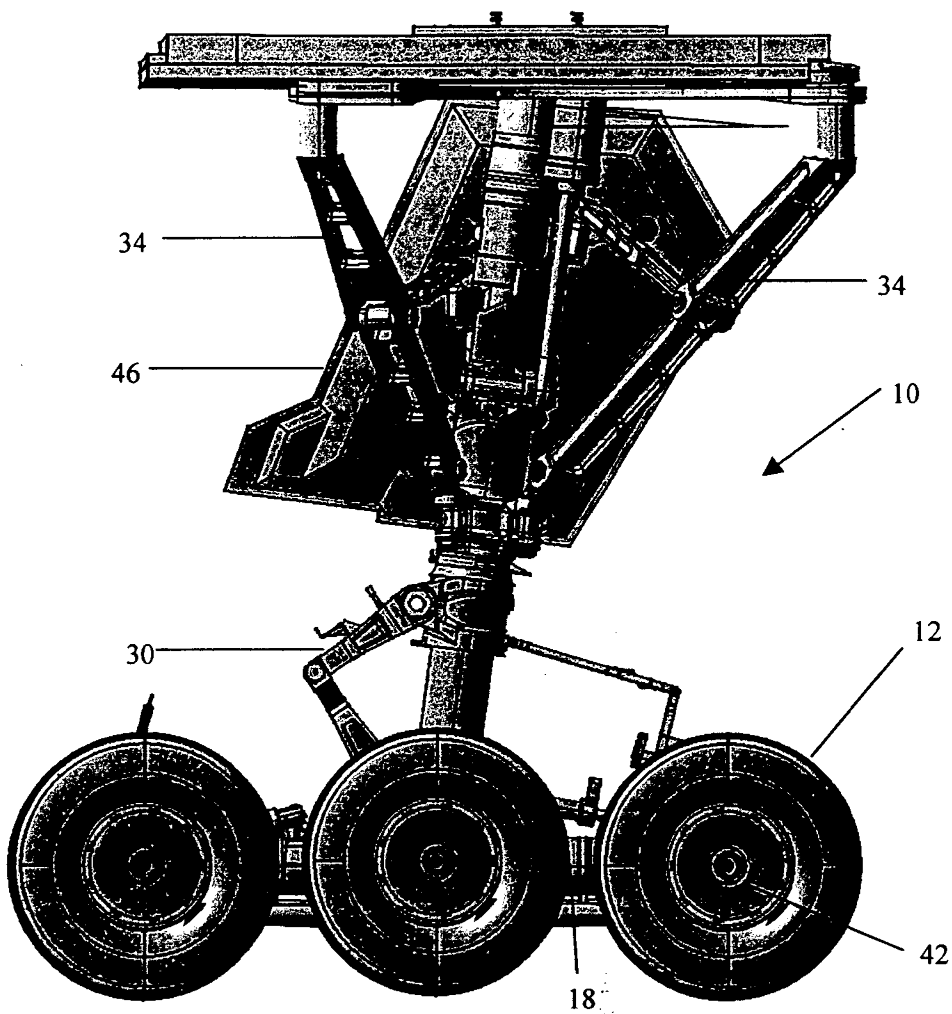


FIGURE 1

PRIOR ART

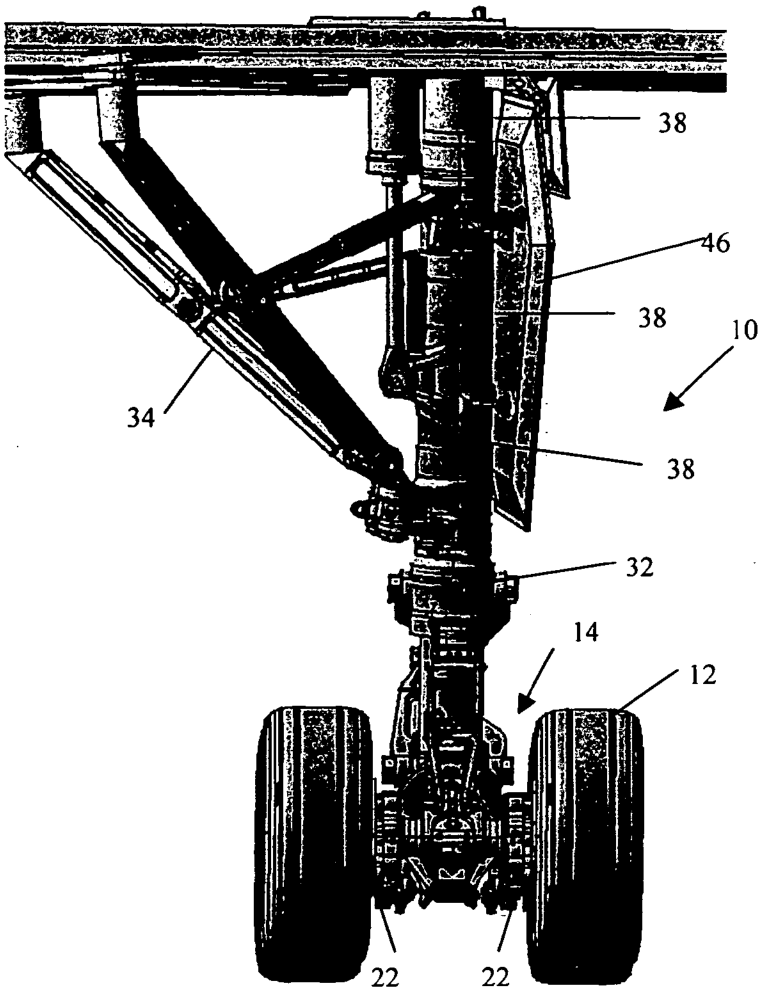


FIGURE 2

PRIOR ART

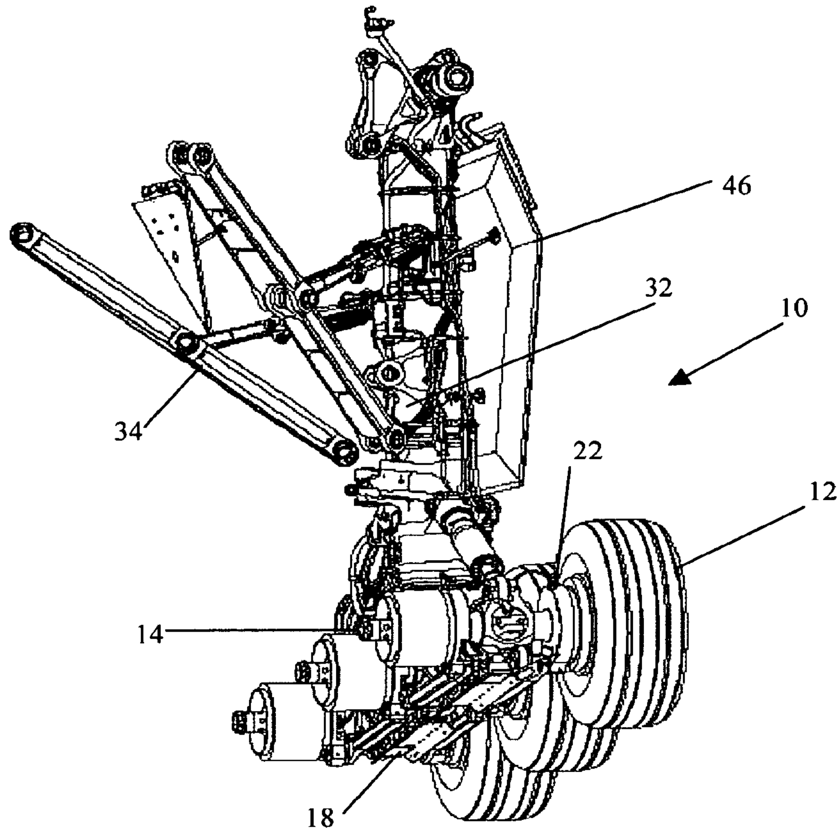


FIGURE 3

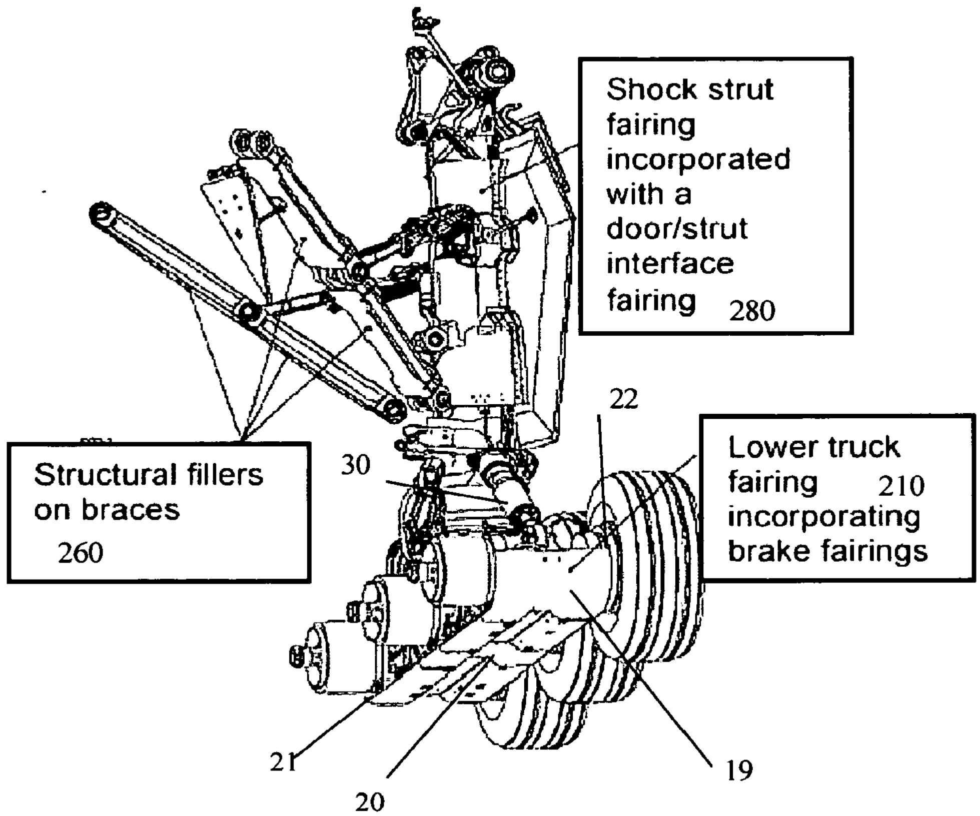

Shock strut fairing incorporated with a door/strut interface fairing 280
22
Lower truck fairing 210 incorporating brake fairings
30
Structural fillers on braces 260
21
20
19

FIGURE 4

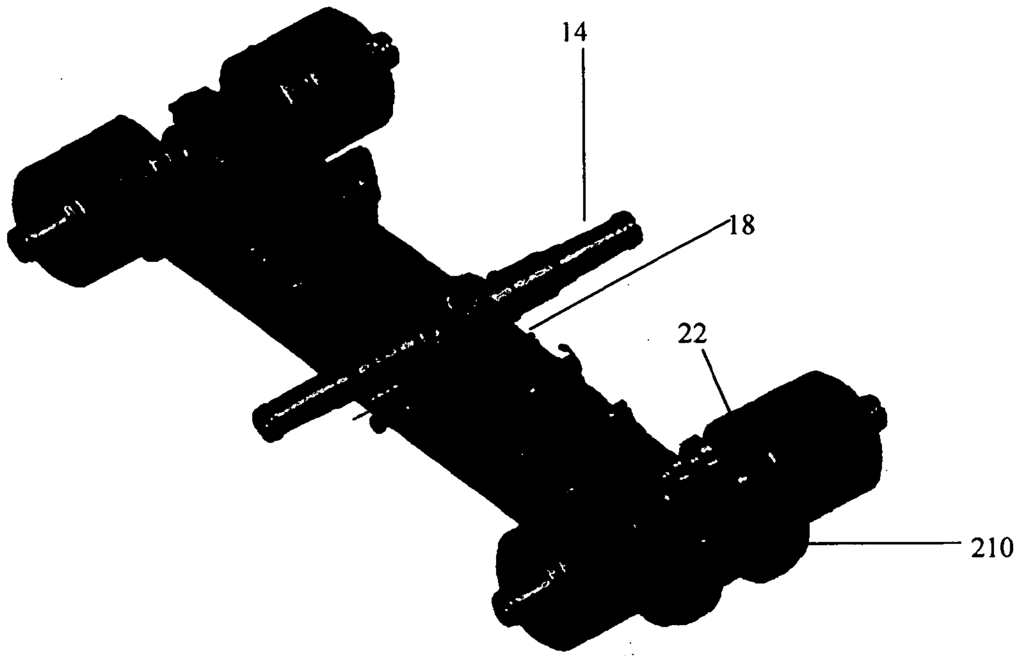


FIGURE 5

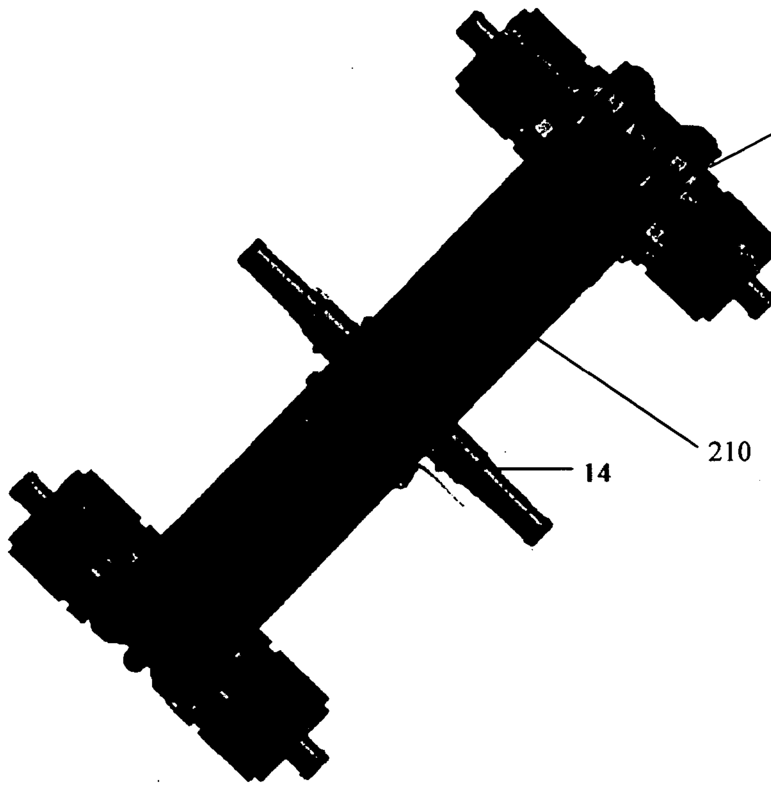
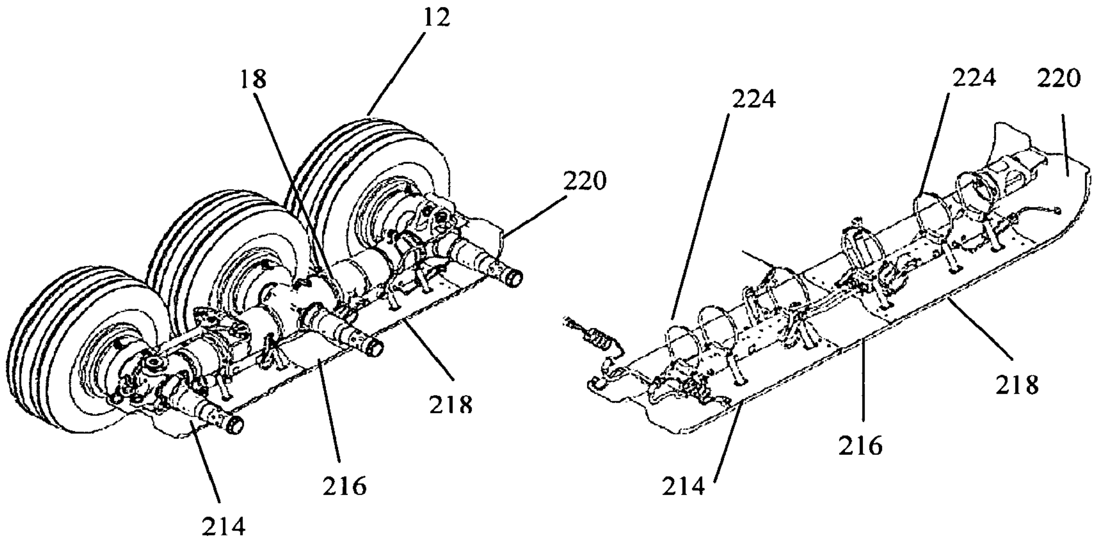


FIGURE 6



FIGURES 7A AND 7B

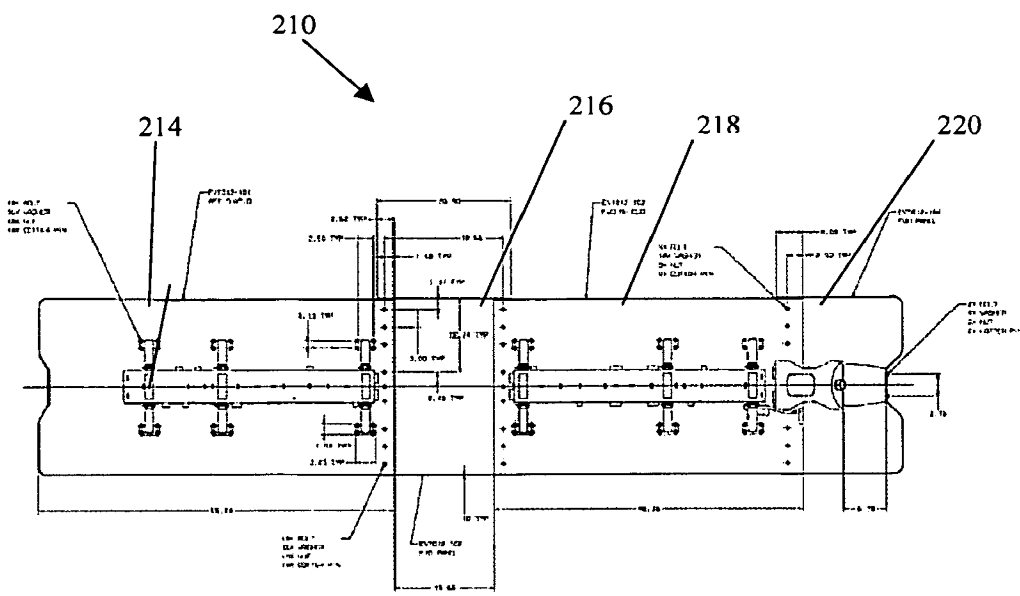


FIGURE 8

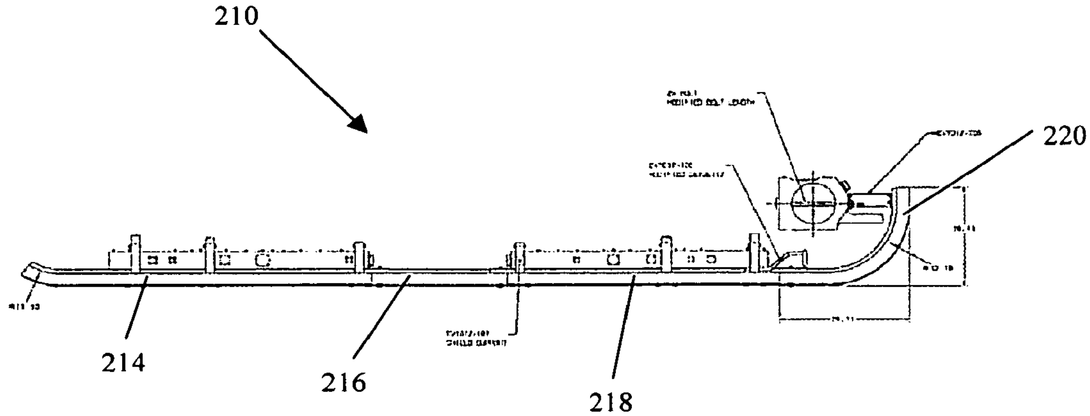


FIGURE 9

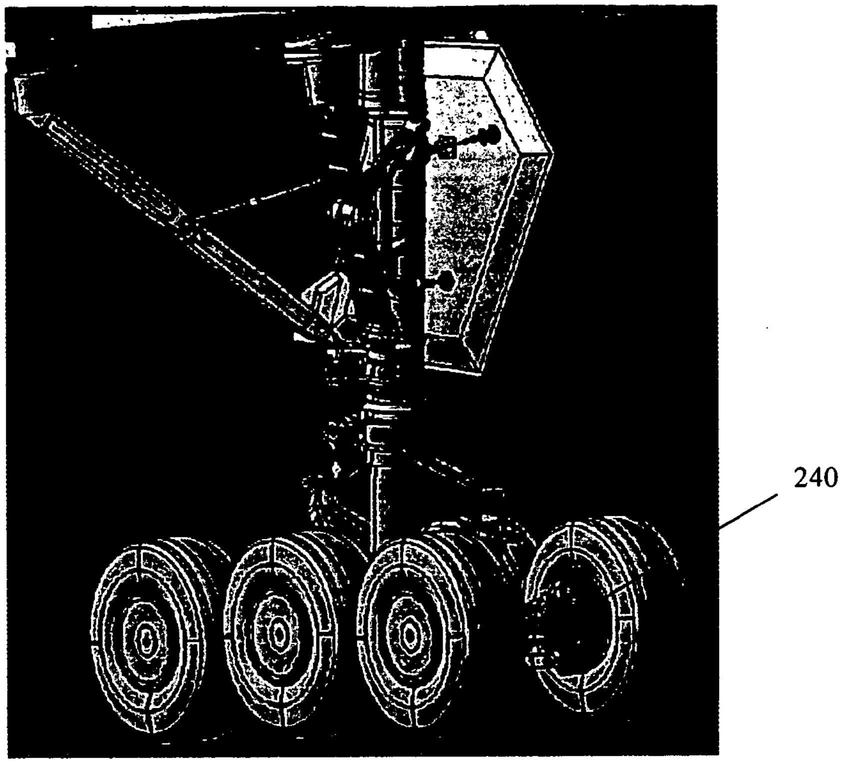


FIGURE 10

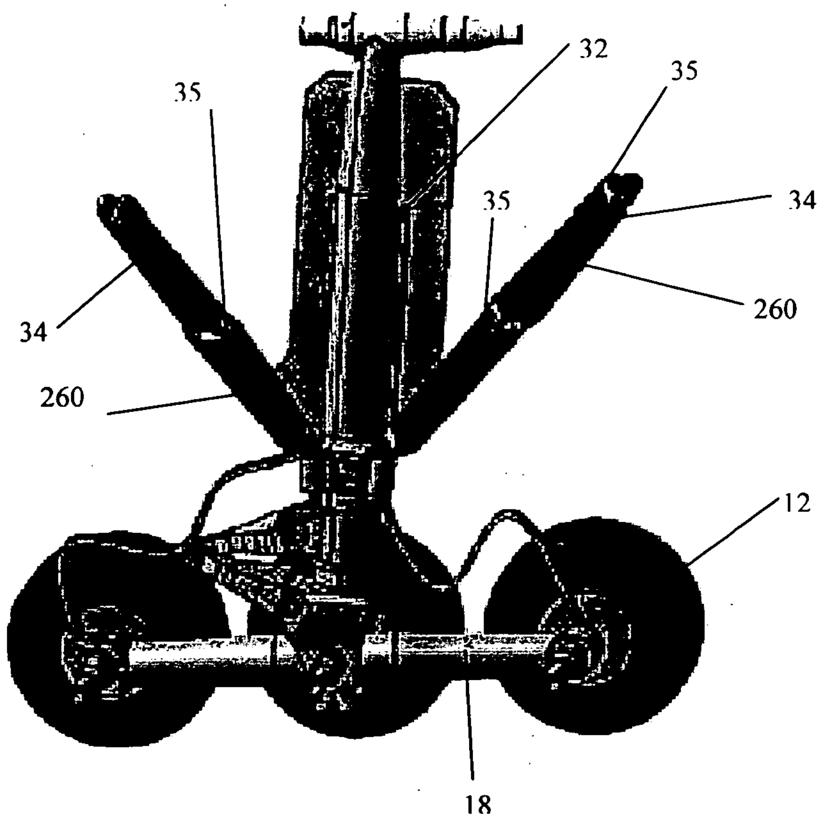


FIGURE 11

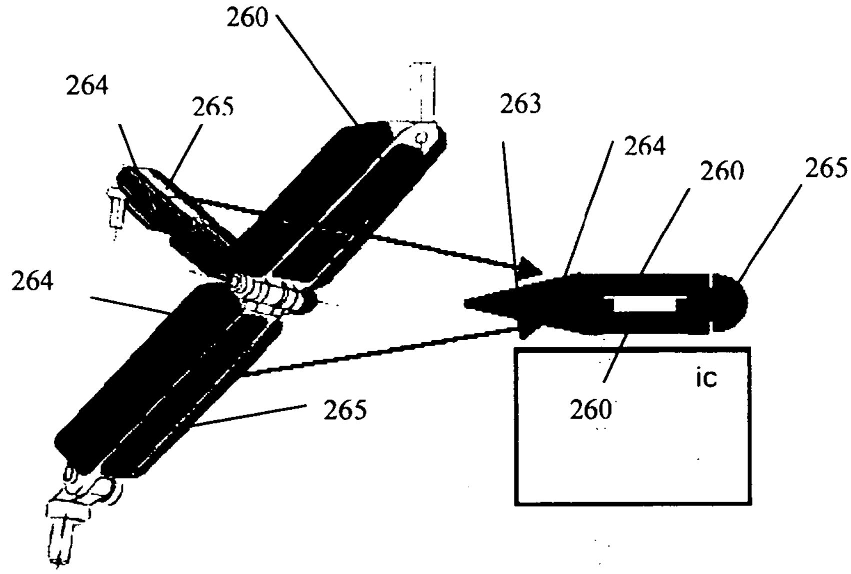


FIGURE 12A

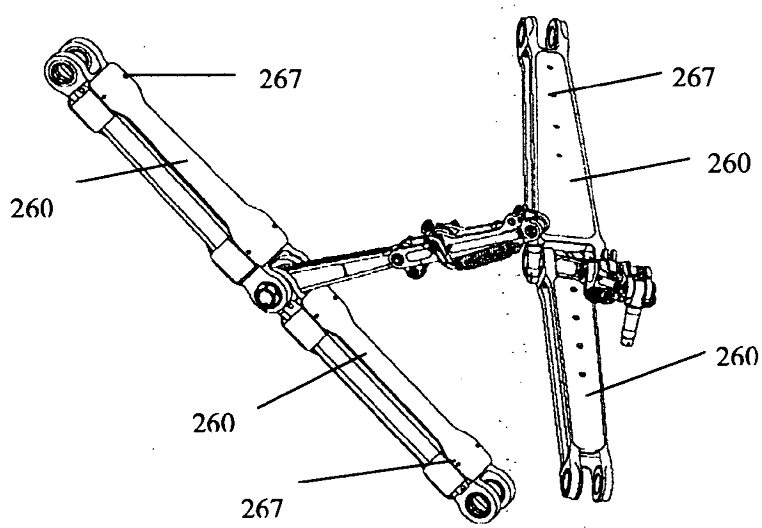


FIGURE 12B

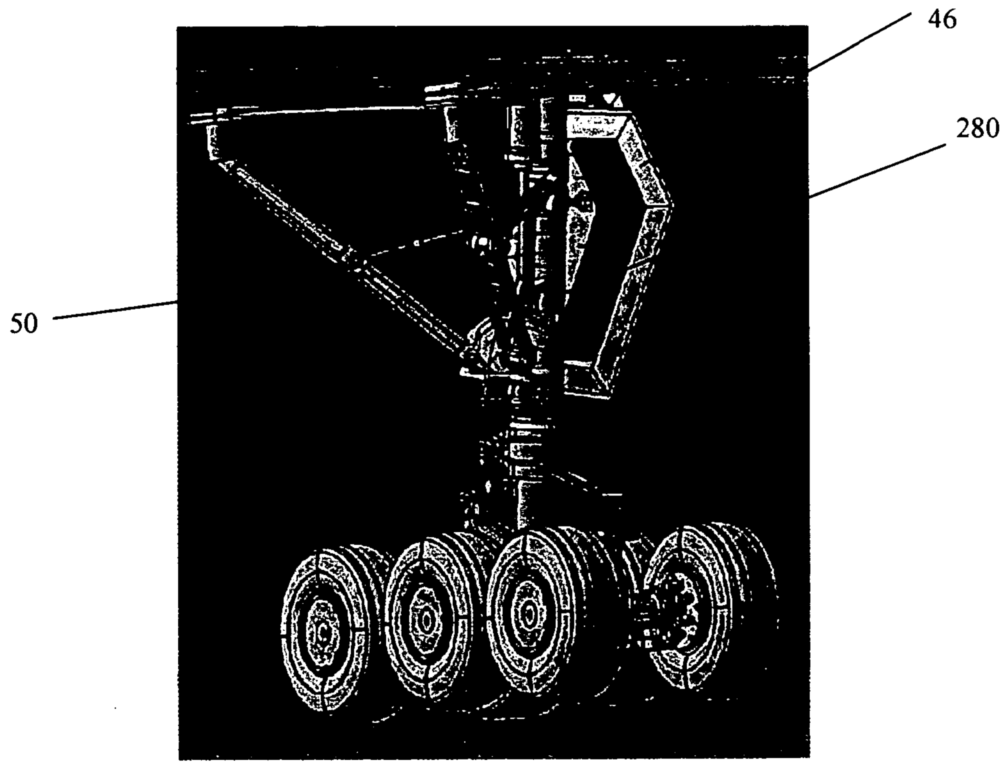


FIGURE 13A

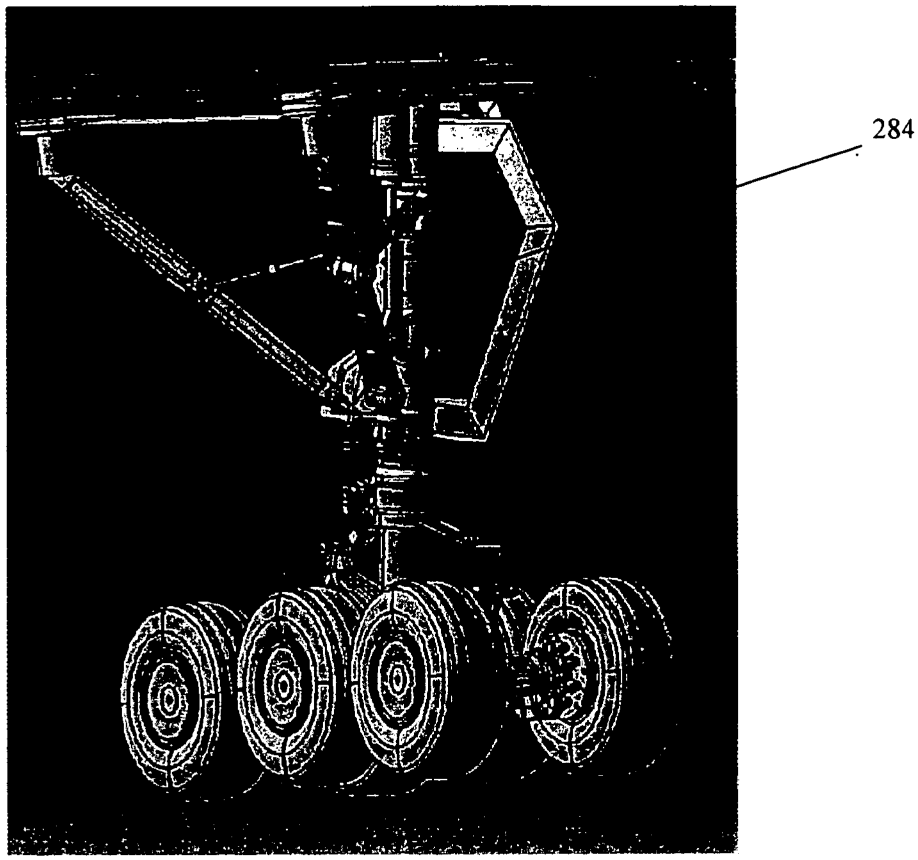


FIGURE 13B

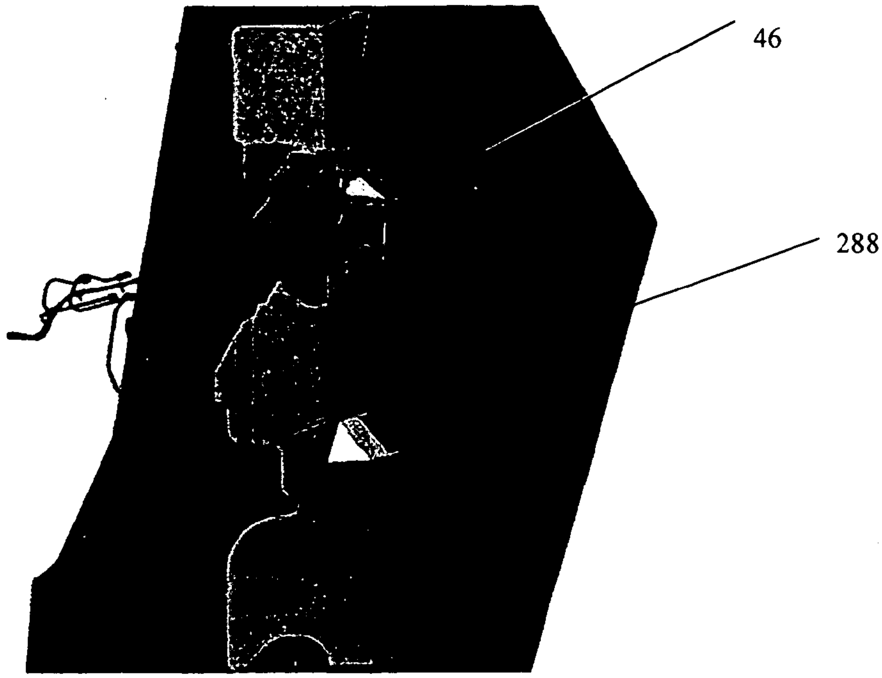


FIGURE 14A

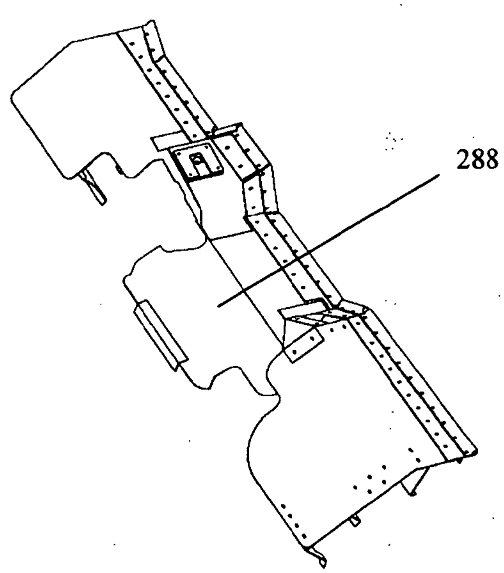


FIGURE 14B

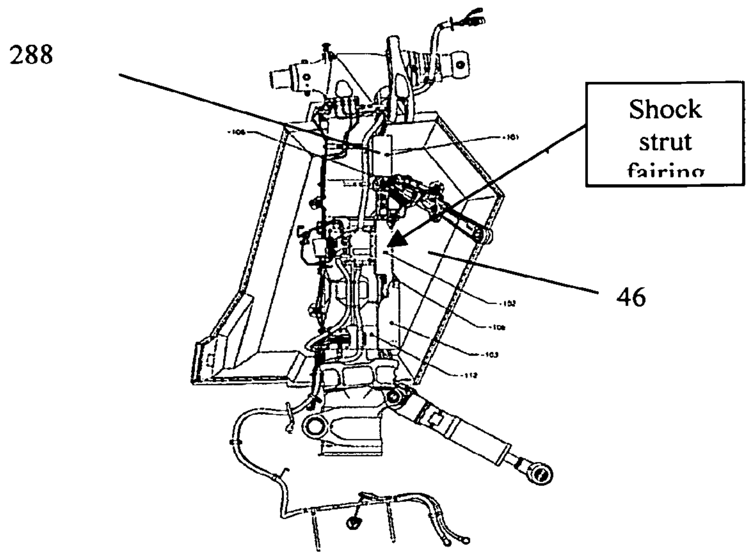


FIGURE 14C

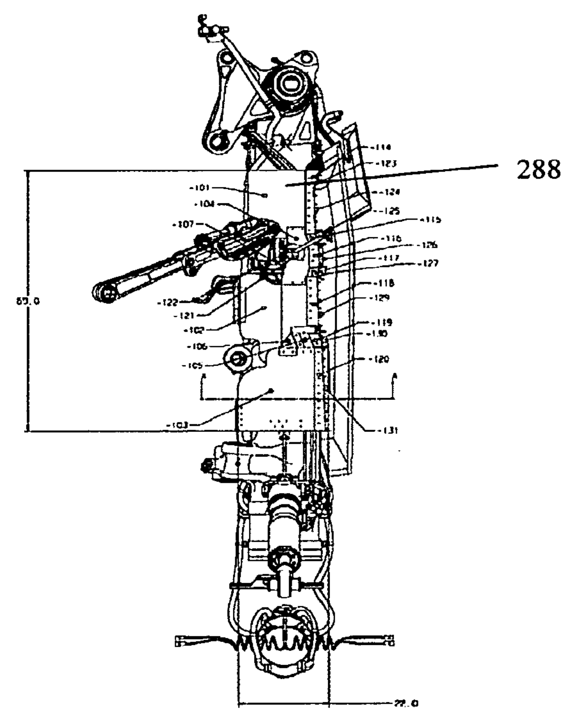


FIGURE 14D

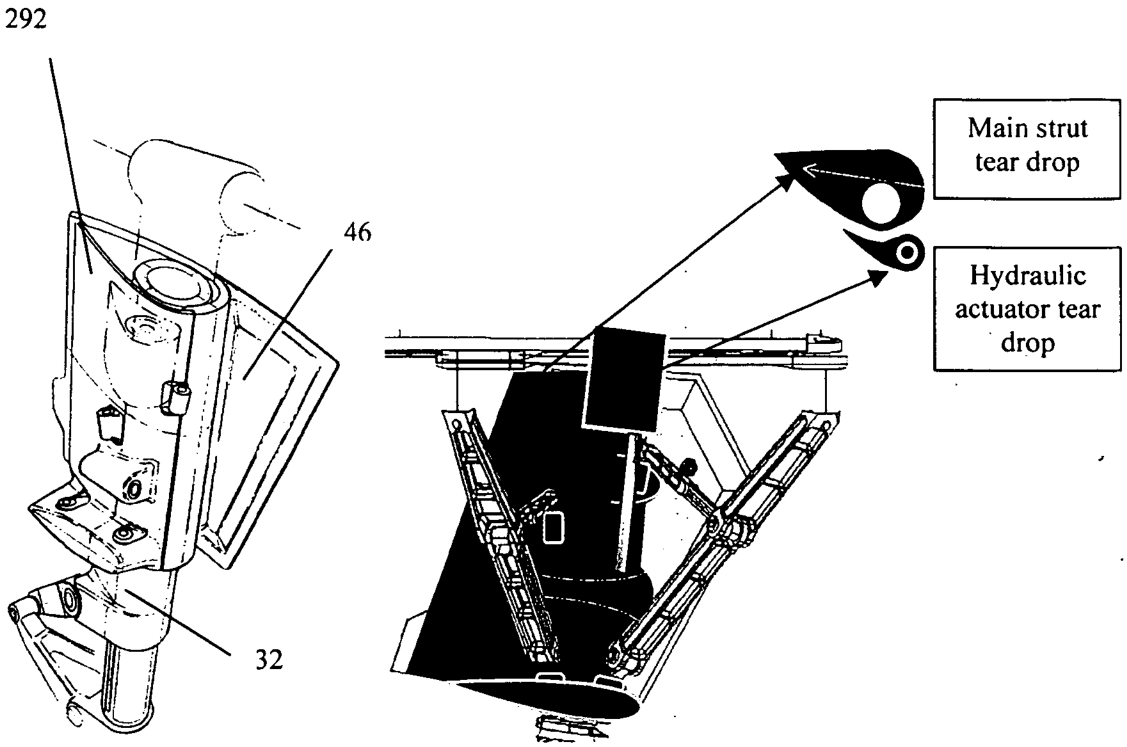


FIGURE 15

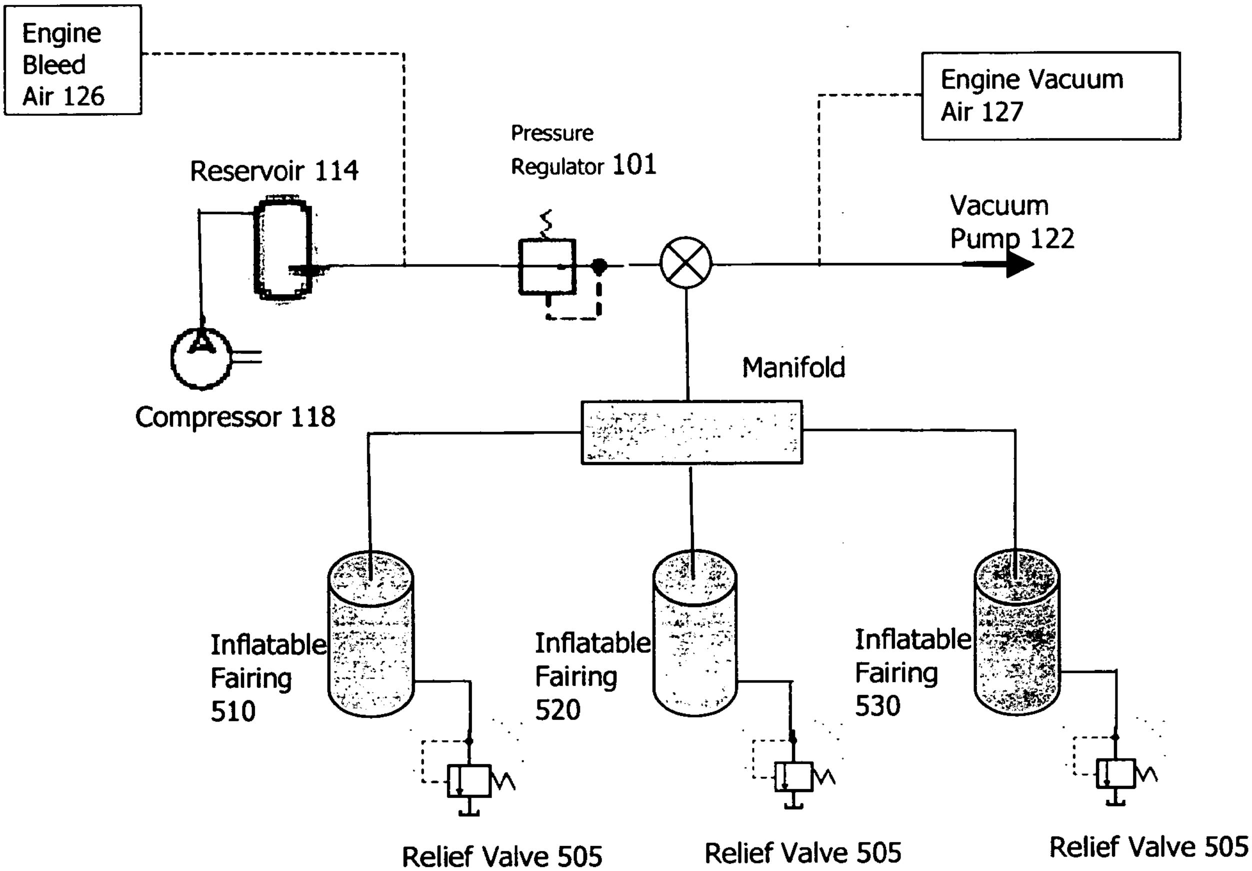
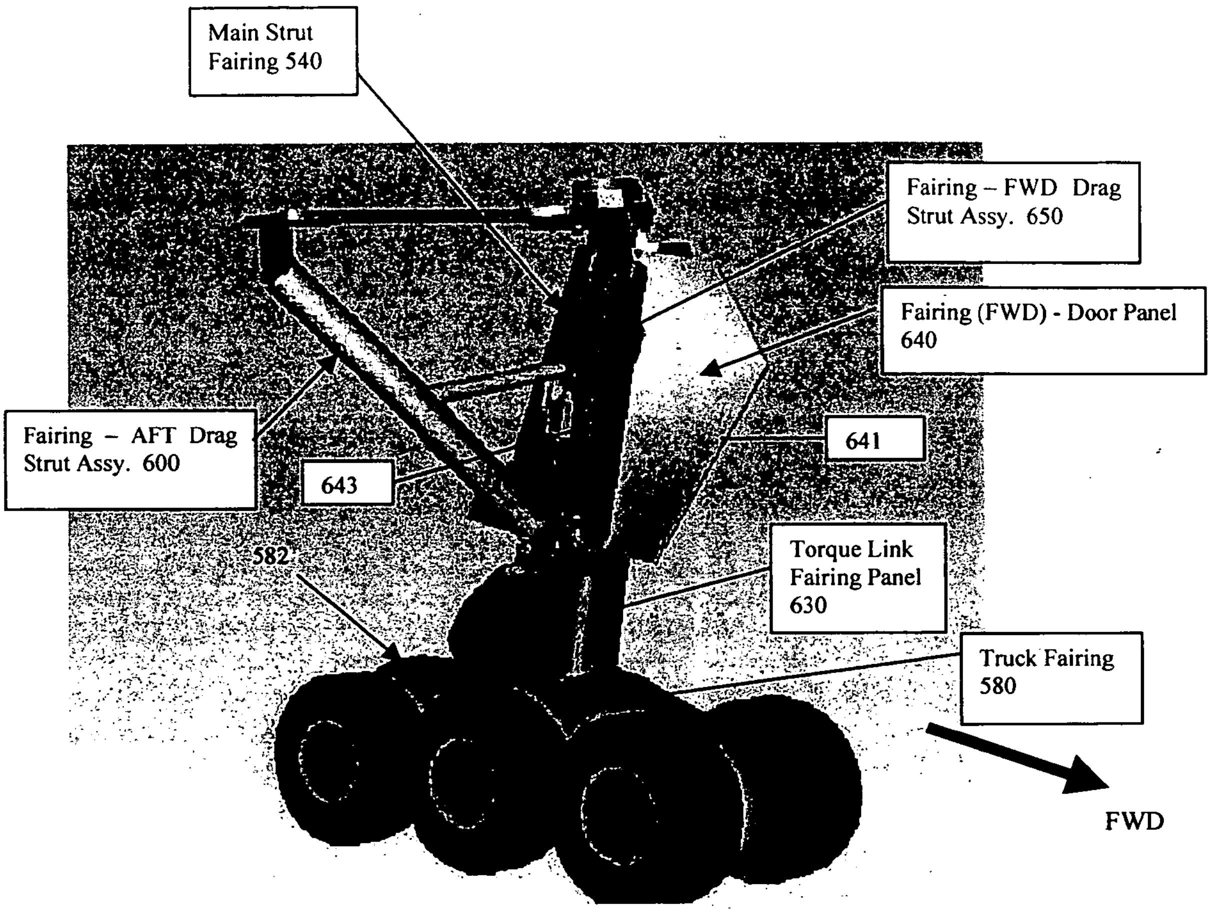

Engine
Bleed
Air 126
Engine Vacuum
Air 127
Pressure
Regulator 101
Reservoir 114
Vacuum
Pump 122
Manifold
Compressor 118
Inflatable
Fairing
510
Inflatable
Fairing
520
Inflatable
Fairing
530
Relief Valve 505
Relief Valve 505
Relief Valve 505

Figure 16



Main Strut Fairing 540
Fairing – FWD Drag Strut Assy. 650
Fairing (FWD) - Door Panel 640
Fairing – AFT Drag Strut Assy. 600
641
643
582
Torque Link Fairing Panel 630
Truck Fairing 580
FWD

Figure 17

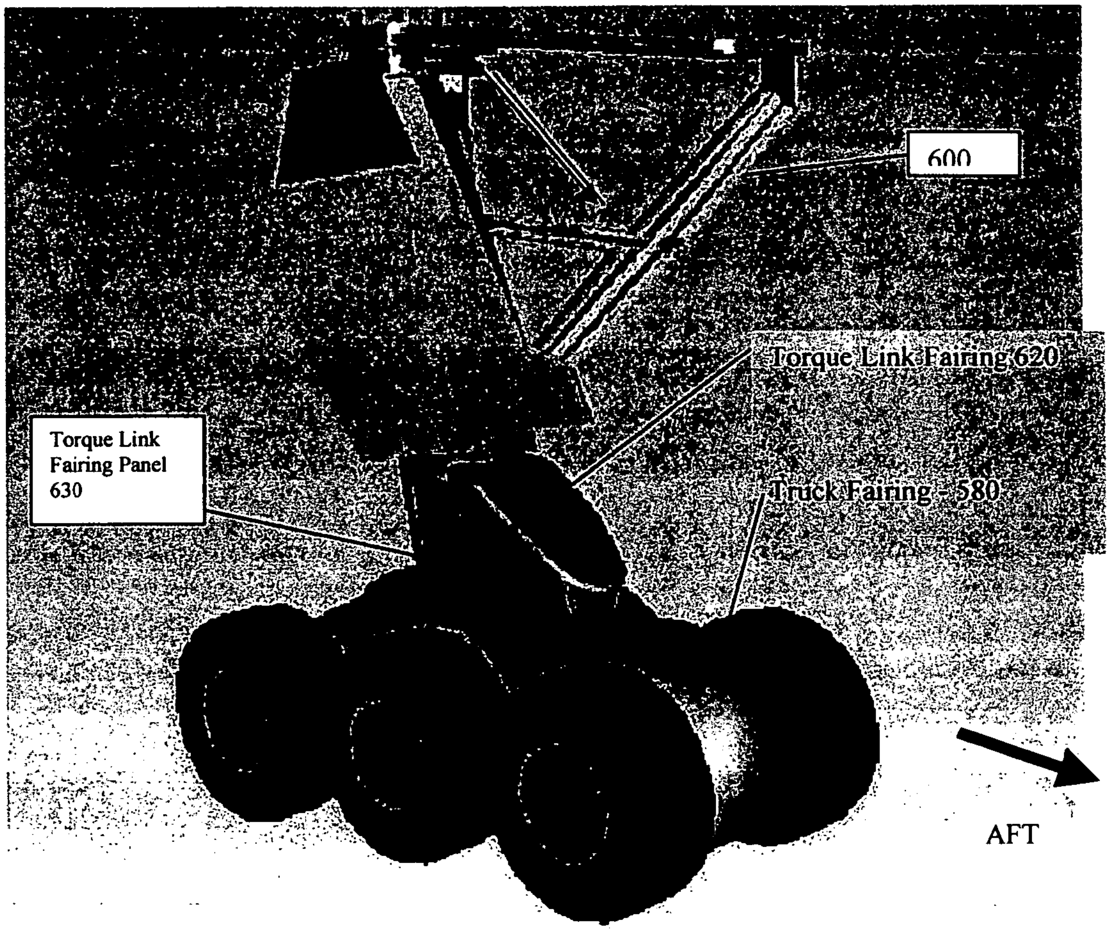

600
Torque Link Fairing 620
Torque Link
Fairing Panel
630
Truck Fairing - 580
AFT

Figure 18

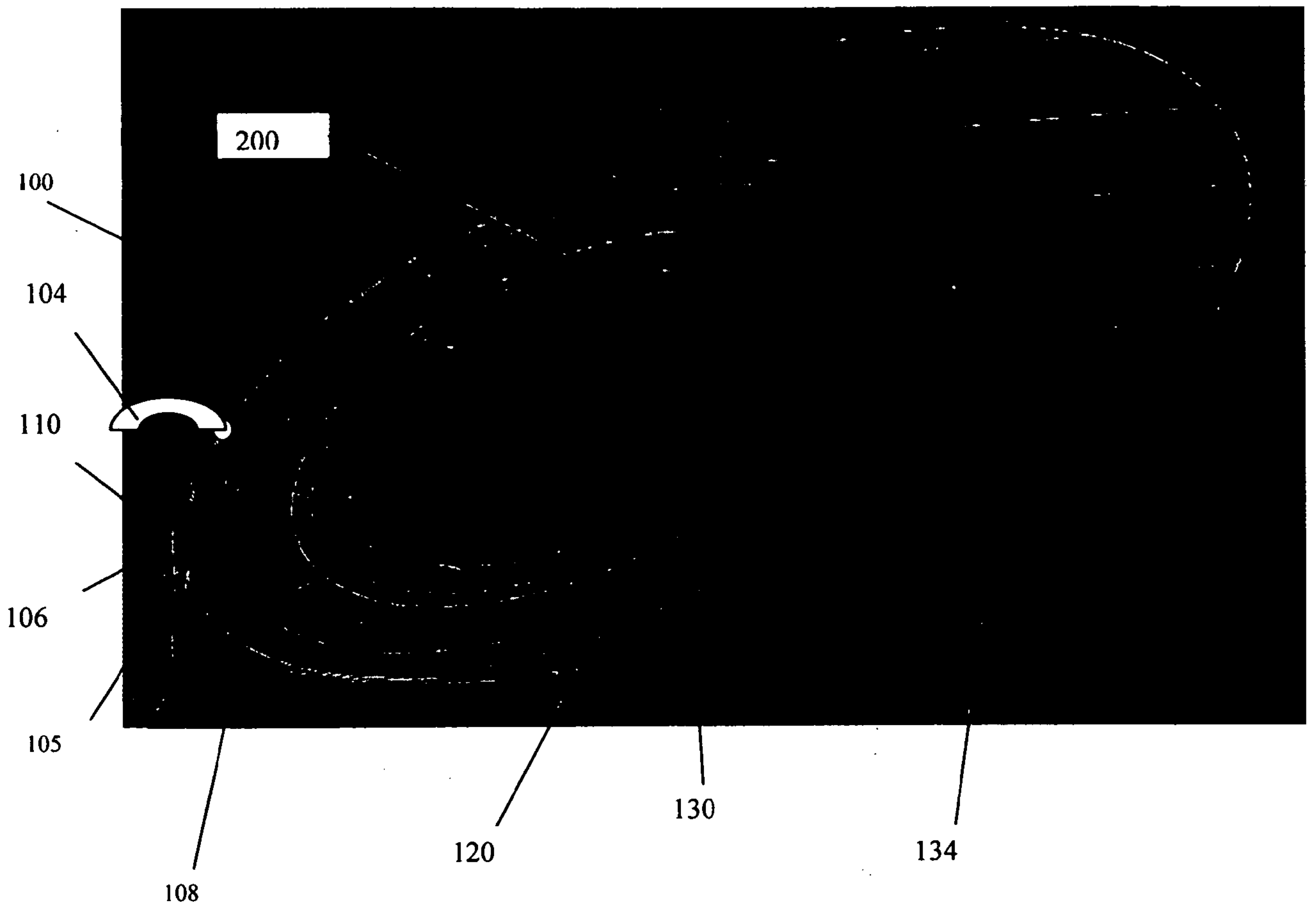


Figure 19

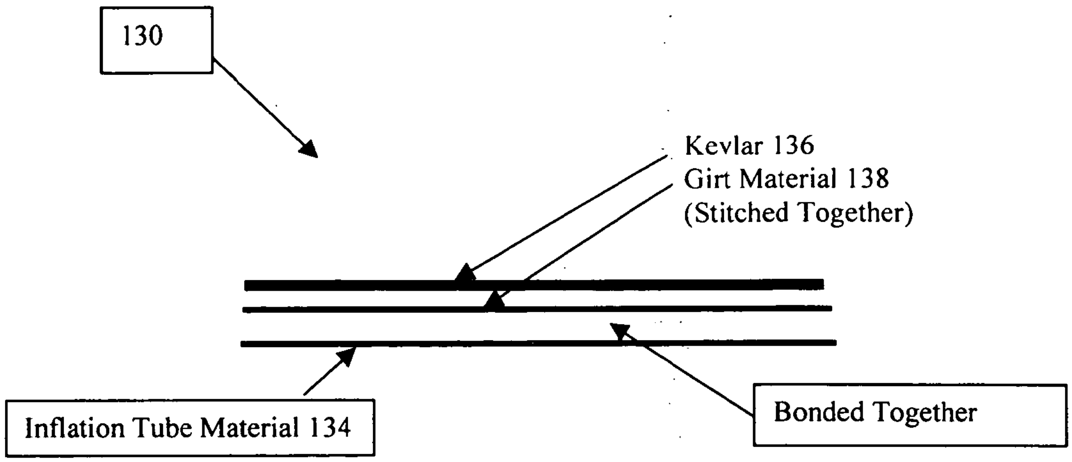

130
Kevlar 136
Girt Material 138
(Stitched Together)
Inflation Tube Material 134
Bonded Together

Figure 20

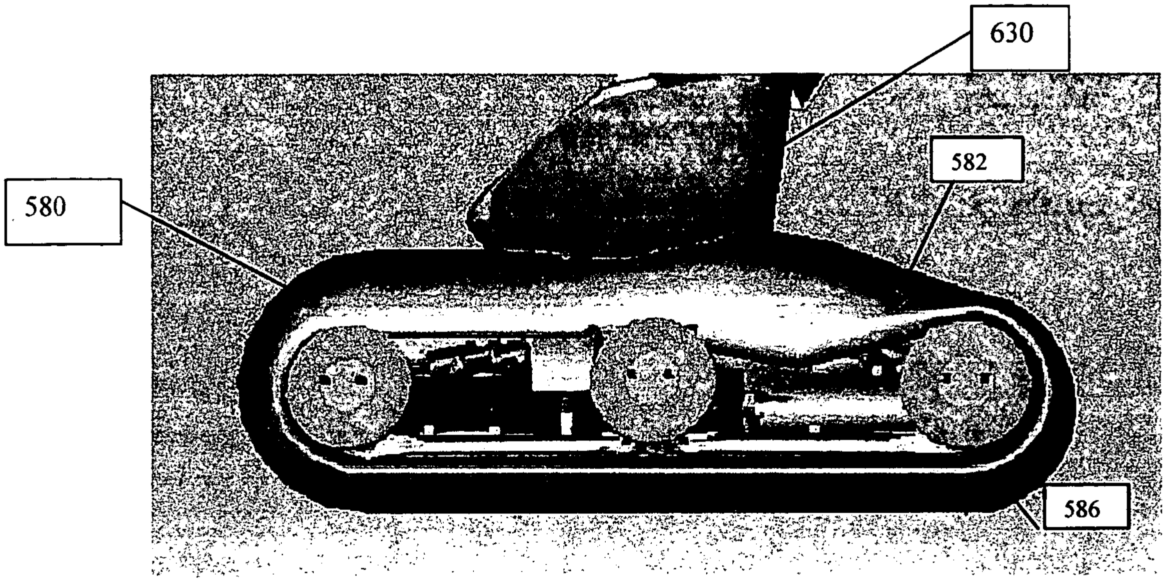


Figure 21

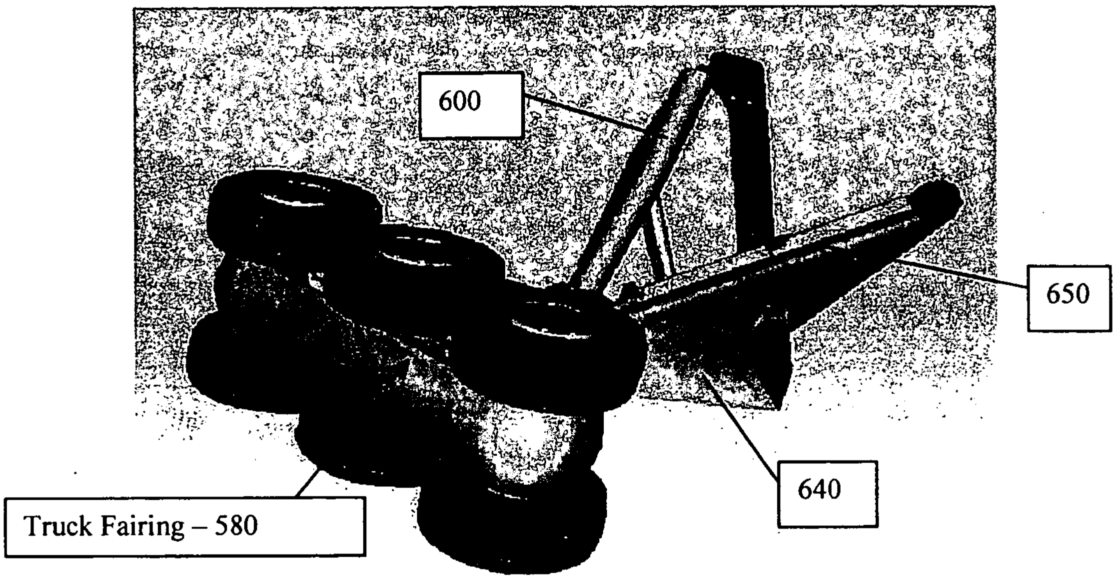


Figure 22

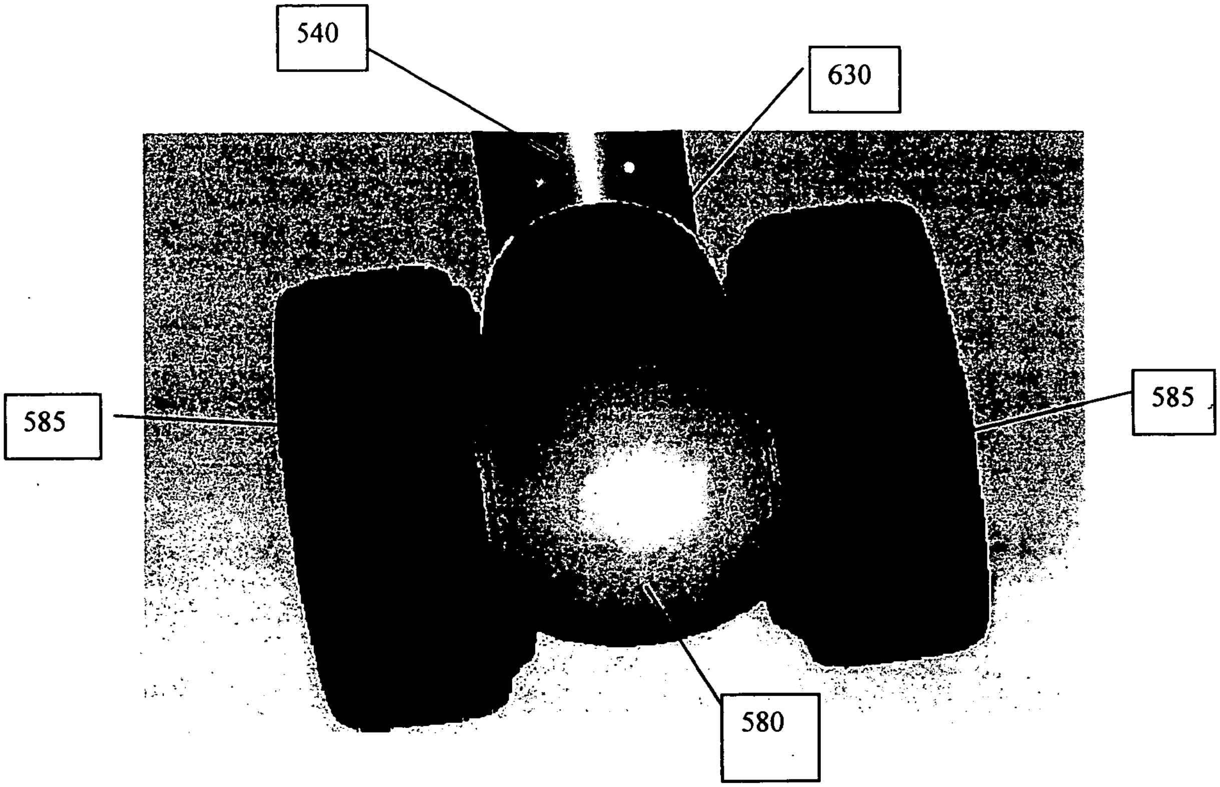


Figure 23

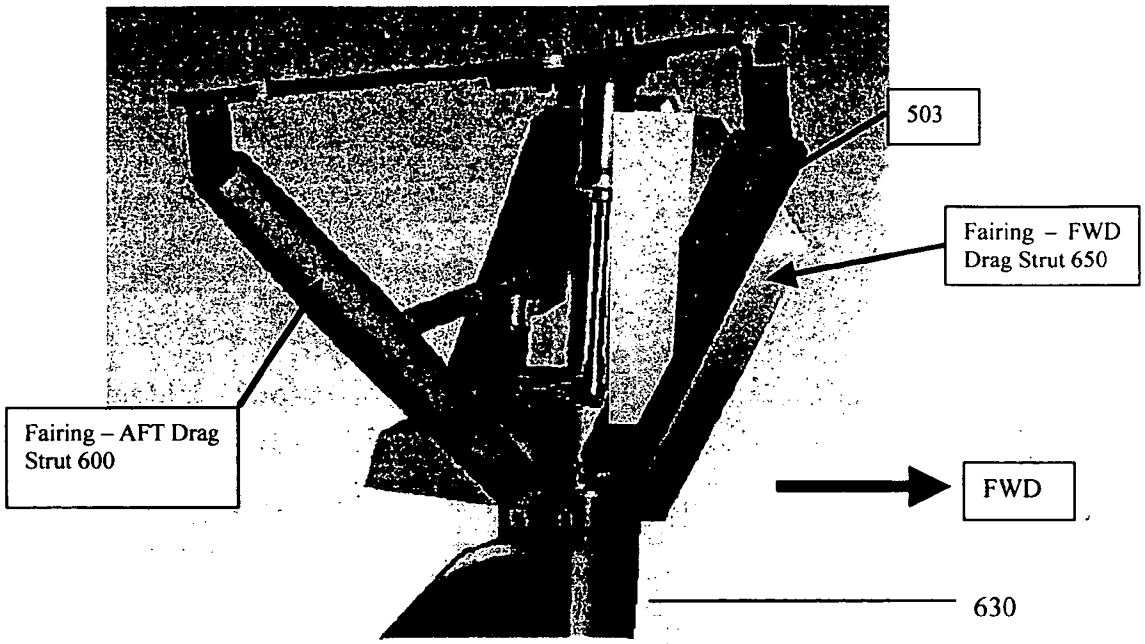


Figure 24
Fairing - Drag Struts

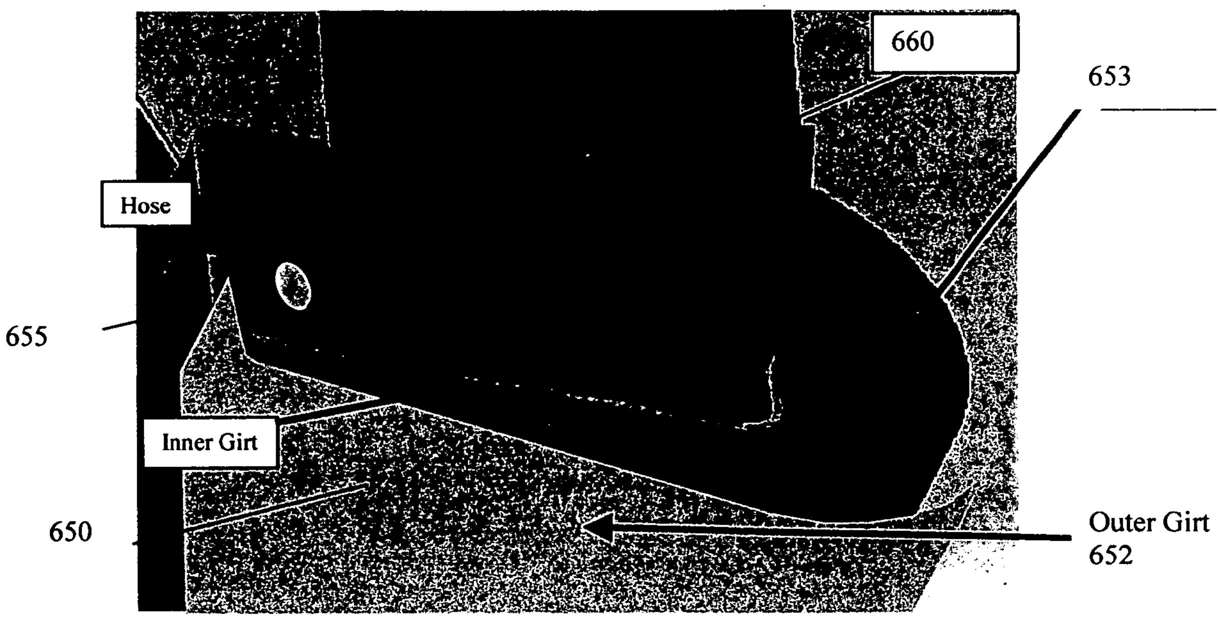


Figure 25
End X-Section of Drag Strut Fairing

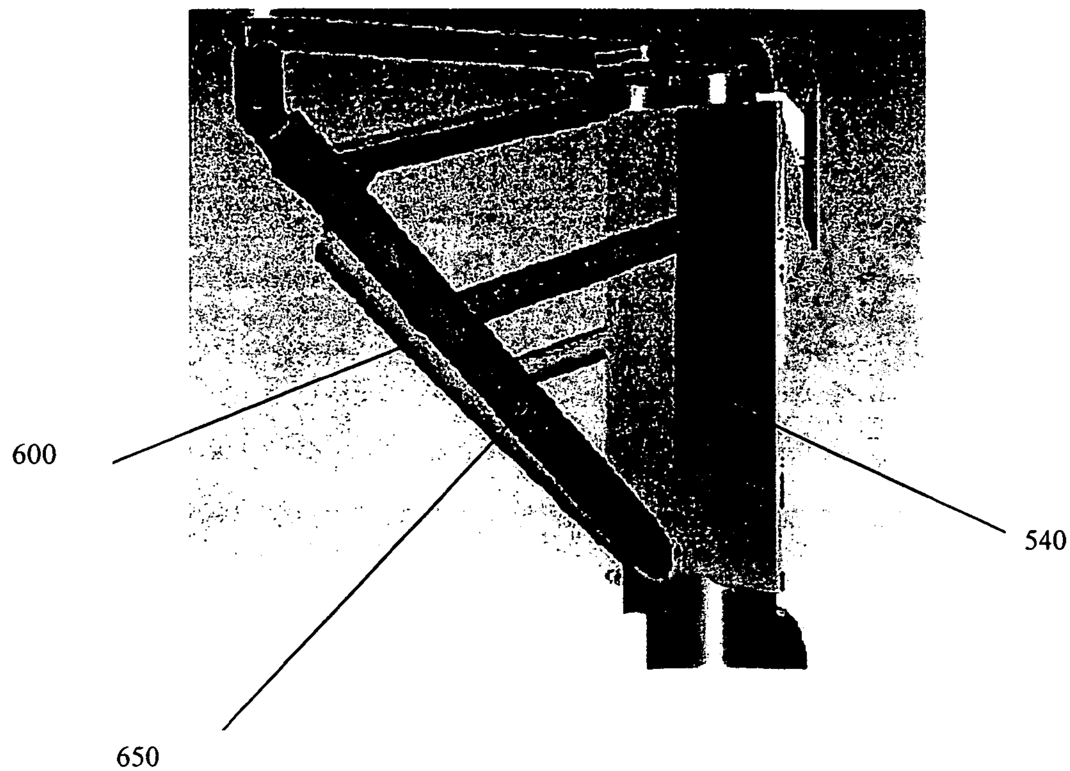


FIGURE 26

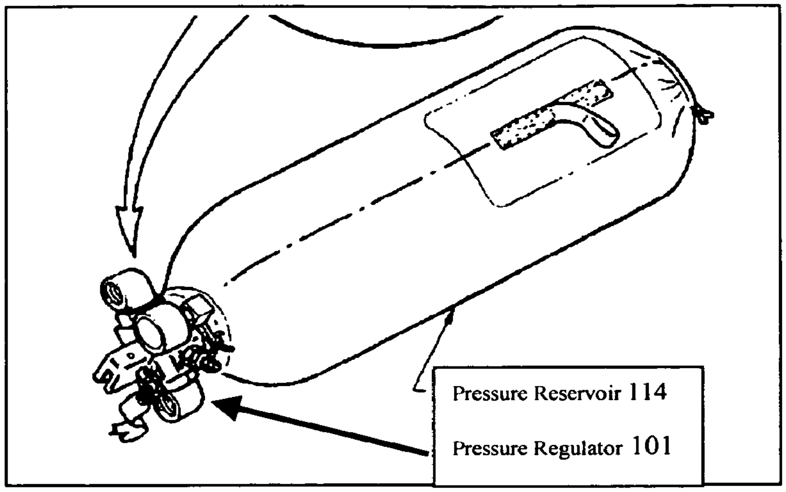


Figure 27